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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F16B 2/14, F16K 11/00

A1

(11) International Publication Number: WO 99/02867

(43) International Publication Date: 21 January 1999 (21.01.99)

(21) International Application Number: PCT/US98/11574

(22) International Filing Date: 4 June 1998 (04.06.98)

(30) Priority Data:
08/893,773 11 July 1997 (11.07.97) US

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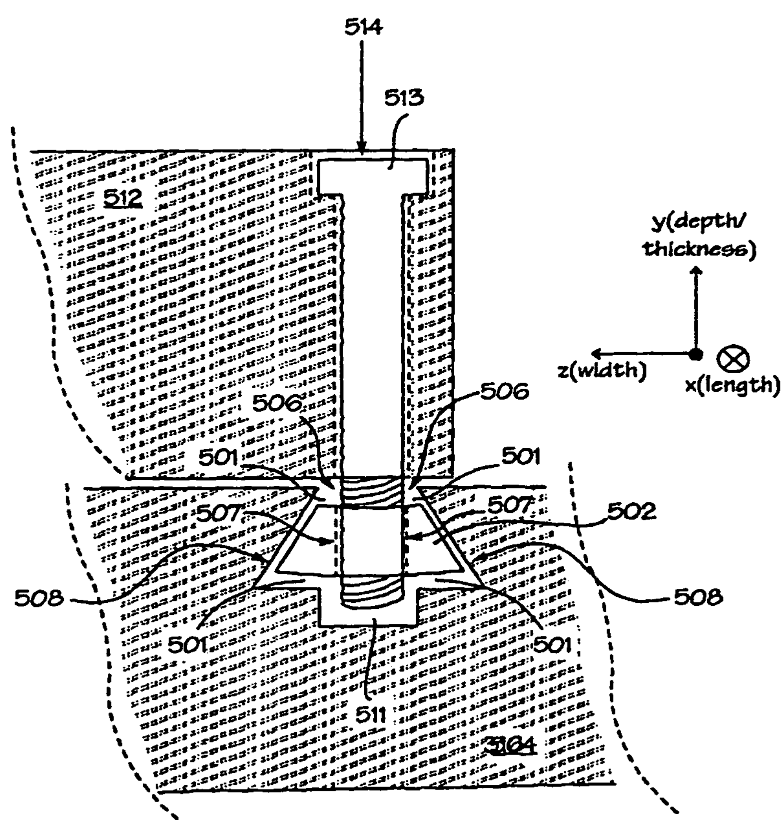
(81) Designated States: AL, AM, AT, AT (Utility model), AU (Petty patent), AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: MOUNTING PLANE FOR INTEGRATED GAS PANEL

(57) Abstract

A mounting plane technology for a gas panel comprising a plurality of discrete blocks (512). The mounting plane (504) of the present invention includes a track (501) and a centering element. The centering element (502) glides along the tracks (501) such that modular blocks (512) may by anchored to any position along the track. Centering elements (502) are easily added to and removed from tracks (501) thus maximizing the speed and flexibility of configuring or reconfiguring the modular blocks (512). The centering element and track have a geometrical symmetry that allows for highly precise anchoring of the modular block with respect to the mounting plane (504). The centering element (502) is harder than the plane material and has grooves to increase the friction between the plane and centering element when the modular block is anchored. Centering elements (502) are deliberately manufactured with a slight asymmetry with respect to the track (501) so that high manufacturing yield is guaranteed. Tracks (501) have devices that enable the centering elements (502) to hold their place against undesired forces.



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MOUNTING PLANE FOR INTEGRATED GAS PANEL

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to the field of gas delivery systems, and more specifically to the mechanism of attachment and reconfiguration of a plurality of blocks which provide the gas routing conduits and passages for a gas panel.

2. DISCUSSION OF RELATED ART

Gas panels are used to control the flow of gases and gas mixtures in many manufacturing processes and machinery. A typical gas panel, such as gas panel 100 shown in Figure 1, is made up of literally hundreds of discreet or individual components, such as valves 102, filters 104, flow regulators 106, pressure regulators 107, pressure transducers 109, and connections 108, connected together by tens (or hundreds) of feet of tubing 110. Gas panels are designed to provide desired functions, such as mixing and purging, by uniquely configuring the various discreet components.

A problem with present gas panels is that most of them are uniquely designed and configured to meet specific needs. Today there is simply no standard design in which gas panels are configured. Today it takes weeks to months to design a gas panel, fabricate all subassemblies, and then assemble the final product. Uniquely designing or configuring each new gas panel costs time and money. Additionally, the lack of a standard design makes it difficult for facilities' personnel to maintain, repair, and retrofit all the differently designed gas panels which may exist in a single facility. The unique designs require an intensive manual effort which results in a high cost to the customer for customized gas panels. Customized gas panels also make spare parts inventory management cumbersome and expensive.

Another problem with present gas panels is a large number of fittings 108 and welds required to interconnect all of the functional components. When tubes

are welded to fittings 108, the heat generated during the welding process physically and chemically degrades the electropolish of the portion of the tube near the weld (i.e., the heat affected zone). The degraded finish of the heat affected zone can then be a substantial source of contaminant generation. Additionally, during the welding process metal vapor, such as manganese, can condense in the cooler portions of the tube and form deposits therein. Also, if elements being welded have different material composition (e.g., stainless steel with inconel), desired weld geometry and chemical properties are difficult to achieve. Thus, gas panels with large numbers of fittings and welds are incompatible with ultra clean gas systems which require extremely low levels of contaminants and particles. Additionally, high purity fittings 108 are expensive and can be difficult to obtain, thereby increasing the cost of any gas panel incorporating them.

Yet another problem associated with present gas panel designs is the large amount of tubing 110 used to route gas throughout the gas panel. Large volumes of tubing require large volumes of gas to fill the system and make it difficult to stabilize and control gas flows. Additionally, gas panels with excessive tubing require significant amounts of time to purge and isolate which can result in expensive downtime of essential manufacturing equipment, resulting in an increase in the cost of ownership. Still further, the more tubing a gas panel has, the more "wetted surface area" it has, which increases its likelihood of being a source of contamination in a manufacturing process.

U.S. Patent Application No. 08/760,150 filed on 12/3/1996 has addressed the above issues by disclosing, as shown in Figs. 2 and 3, modular building blocks for an integrated gas panel. The use of such building blocks greatly simplify the design and reduce the technical shortcomings associated with current gas panel technology. This invention relates to the mechanism employed for mounting the modular blocks. It is possible to mount the modular building blocks by individually drilling and tapping mounting holes in a customized pattern into a planar base fixture. Such a customized mounting plate will anchor the modular blocks with sufficient accuracy such that the low tolerance requirements of the block to block misalignment (+/- .003") are met. However, customized drilling is both expensive and time consuming. Furthermore, easy reconfiguration of an existing gas panel is impossible if the reconfigured gas panel design has a different mounting hole footprint than the previous gas panel design. A breadboard-like mounting plate with pre-drilled and tapped mounting holes located at periodic

locations on the mounting plate is also possible. Such a mounting plate eliminates the wasted time and money devoted to a customized mounting plate. However, a breadboard like design limits the total number of possible configurations on a mounting plate. That is, the modular blocks are not capable of being anchored at any of a continuous range of positions, but rather, their positions are limited to the relatively few discrete locations that are determined by the placement of the pre-drilled holes. Furthermore, a breadboard-like mounting plate forces the dimensions of the modular blocks to conform to the dimensions of the periodical spacing of the pre-drilled holes. This results in wasted space and possibly incompatible downstream product offerings. Additionally it is highly desirable to have a mounting technology that allows for the reconfiguration of gas panel even if the gas panel is fixed in a vertical position (for example on a wall). Such a capability would not even require that the gas panel be taken down in order to be reconfigured.

Thus, what is desired is a versatile mounting technology for a modular gas system that: 1) is easy to manufacture; 2) allows for rapid configuration or reconfiguration of a gas panel; 3) maximizes the available positions where modular blocks may be mounted; 4) allows for highly precise anchoring of modular blocks and 5) allows for reconfiguration even if the mounting fixture remains fixed in a vertical position.

SUMMARY OF THE INVENTION

The present invention is a mechanism for rapidly configuring (or reconfiguring) and accurately mounting to a planar surface a set of uniquely ported and passage routed modular blocks which can be coupled together to form a weldless and tubeless gas panel. This mechanism maximizes the positions where the modular blocks may be placed, allows for easy and rapid configuration or reconfiguration and also allows the gas system to be configured while the mounting fixture is vertical. Each embodiment consists of lengthwise tracks and centering elements. The centering elements run along the length of the tracks and precisely anchor the modular blocks at any position across the length of each track. The mechanism for centering the modular blocks with high precision involves moving a centering element with a narrowing width into a cavity with substantially the same narrowing width. As the centering element presses snug against the wall of the

cavity its location with respect to the mounting plane is centered within the cavity. Additionally, the centering elements have grooves on the surface that interface with the cavity wall in order to increase the friction at the interface resulting in a stronger anchor for the modular blocks. Additionally the cavity material is softer than the centering element. Again, this results in stronger anchoring. Further still, the narrowest width of the centering element is larger than the smallest width of the cavity so that the centering element does not distort or pull through an opening in the cavity.. Furthermore, the centering elements are purposely manufactured such that their width narrows at a slightly greater rate than the rate at which the cavity narrows. This ensures that all centering elements will fit inside all cavities, thus manufacturing yield is maximized. Finally, the centering elements may be held vertically by the use of springs that press the centering elements against the walls of the cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an illustration of a standard gas panel which utilizes tubing and welds to interconnect the various functional components.

Figure 2 is an illustration of a gas panel comprising modular building blocks.

Figure 3a and 3b is an illustration of a gas stick comprising modular building blocks.

Figure 3c is an illustration of an end plate of a gas stick aligned on the mounting plane with an alignment pin.

Figure 4 is an illustration of a gas panel comprising modular building blocks and a novel mounting plane system.

Figures 5a, 5b and 5c are illustrations of the preferred mounting plane.

Figures 5d and 5e are illustrations of a preferred centering element.

Figure 5f is an illustration of a modular building block centered in the mounting plane.

Figures 6a, 6b and 6c are schematic illustrations of a second embodiment of the present invention.

Figure 6d is a schematic illustration of a third embodiment of the present invention.

Figures 7a and 7b are illustrations of a spring used to hold a centering element in place.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

The present invention describes a novel mechanism for mounting a set of modular blocks which can be interconnected together to form a gas panel having a variety of different functions and capabilities. In the following description numerous specific details are set forth, such as particular fixtures, components, and mounting plane designs, in order to provide a thorough understanding of the present invention. It will be obvious, however, to one skilled in the art that the present invention may be practiced without these specific details. In other instances well known mechanical assembly, machining and manufacturing techniques have not been set forth in particular detail in order to not unnecessarily obscure the present invention.

The present invention is a versatile mounting plane having numerous tracks that guide centering elements. The modular blocks are then mounted to the centering elements. Not only do the centering elements and tracks allow for a continuous range of locations where a modular block may be placed on a track, they also serve as a mechanism for achieving highly precise anchoring of the modular block to the planar structure. Additionally, the building blocks may be quickly and easily configured or reconfigured on a mounting plane. That is, the tracks and centering elements are deliberately designed so that the centering elements: 1) are easily removed or added to tracks; 2) easily glide along any track across a continuous range of positions and 3) are used to quickly mount the modular block to the mounting plane. In this sense, a versatile plane ("mounting-

plane") is realized that substantially eliminates the inefficiencies associated with traditional gas panels. Additionally, the tracks may contain a spring that is designed to prevent the movement of centering elements against undesired forces (such as gravity or external shock) that act to move the centering element along the track. Additionally, the mounting plate may be reduced to a single track so that individual gas sticks may be built. These individual sticks may then be added to a larger framework capable of holding many such single track mounts in order to form a complex integrated gas system.

The present invention is a mounting-plane mounting apparatus for a set of uniquely ported discrete building blocks which, when interconnected together, form all of the conduit and manifold routing required for a complete gas panel. The building blocks can be coupled together to form gas panels, such as gas panel 200 shown in Figure 2, which can provide all of the different functions and capabilities required of current gas panels. Gas panel 200 shown in Figure 2 includes a plurality of modular base blocks 202 which have a standard component interconnection face. A plurality of modular base blocks are coupled together to form a common conduit or gas stick 207. A plurality of manifold blocks 204 are coupled together in a direction transverse to the coupling of the base blocks to form a common manifold or passage, which runs transverse to the conduits or gas sticks formed by coupled adjacent base blocks. The manifold blocks are coupled to the under side of base blocks (i.e., to the side opposite to the side on which the component 206 is mounted) and allow for fluid communication between the individual gas sticks.

The common or standard port locations for the base blocks 202, manifold blocks 204, and assorted functional elements 206 enable neighboring blocks and/or elements to contribute to a continuous gas system. In order to construct such a system, neighboring base blocks 202 and/or manifold blocks 204 must be anchored to the mounting plane 208 with a high degree of precision.

Figs. 3a and 3b show a gas stick 300 composed of neighboring base blocks 301 through 30x. Fig. 3a shows a top view and Fig. 3b shows a side view. Beneath the base blocks 301 and 30x are manifold blocks 310 through 31y and 320 through 32y. At the interfaces 303 of the base blocks, the gas port 304 on each face must be aligned with sufficient precision to properly couple the gas lines 305 that are located within each base block 301 through 30x. That is, a gas stick is a continuous channel for gas that is made up of a plurality of blocks. In order for the

gas system to be properly functional, the blocks must have minimal misalignment with respect to the ports on the face of neighboring blocks. Furthermore, the interface between neighboring blocks must be tight enough to form a sufficient seal. In order to accomplish this, the base blocks 301 through 30x are lined up on a separate alignment fixture (not shown). The alignment fixture is a corner-like bracket (e.g. two metal planes that meet at a 90 degree angle). The alignment fixture is used to align the base blocks 301 through 30x that make up a gas stick 300. When the base blocks 301 through 30x are aligned on the alignment fixture, end plates 306 are added on both ends of the gas stick 300. Each base block also has a pair of holes that are located on both sides of the gas port 304. These holes run through the end plate 306 and each base block, along the x axis. Two bolts 307 are inserted through each pair of holes for each base block 301 through 30x, through the entire length of the gas stick 300, while the base blocks 301 through 30x are aligned on the alignment fixture. Bolts 307 are double threaded so that nuts 312 may be threaded on each end of each bolt 307. Nuts 312, when tightened, press end plates 306 and base blocks 301 through 30x against one another tightly such that a tight seal at ports 304 at each block to block interface 303 is formed. Bolts 307 and the alignment fixture help preserve the block to block alignment of gas stick 300 while nuts 312 are tightened against the end plate 306. After the nuts 312 are tightened and the gas stick is removed from the alignment fixture the gas stick 300 is ready to be mounted to the mounting plane 311. The bottom of end plates 306 do not touch the surface of the mounting plane 311 allowing manifold blocks 310 through 31y and 320 through 32y to run transverse to the gas stick 300 between the gas stick 300 and the mounting plane 311. The gas sticks 300 are mounted to the manifolds 310 and 320 at base blocks 301 and 30x. Alignment pins 313, shown in Fig. 3c, are used to ensure that the gas stick 300 is properly aligned to the lengthwise (x) axis prior to the gas stick being mounted to manifold blocks 310 and 320. Alignment pins 313 are mounted to a track 316, as shown in Fig. 3c, with a alignment pin bolt 314 and dovetailed shaped nut 315. As will be discussed later, the shape of the track 316 and the shape of the dovetailed shaped nut 315 guarantee that the alignment pin bolt 314 and the alignment pin 313 are centered in the middle of the track 316. Alignment pins 313 are centered to the track 316 on either end of the gas stick 300 so that when bridge 317 on the underside of the end plate 306 slips over the alignment pin 313 the gas stick is also aligned on the track (i.e. x axis). The bottom of the end

plate 306 does not touch the surface of the mounting plane so that the gas stick 300 is easily aligned to the x axis and so that the manifold blocks may pass underneath the gas stick 300. Referring back to Figs. 3a and 3b, in order to secure proper alignment, the mounting technology, not only of the base blocks 301 - 30x to each other or the base blocks 301 and 30x to manifold blocks 310 and 320, but also of the manifold blocks 310 and 320 to the mounting plane 311 is critical. Specifically, there must be negligible deviation, with respect to manifold block 310, of the position of manifold block 320 in the y and z directions. Furthermore, the blocks must be easily and quickly placed and anchored to various positions on the mounting plane 311. Fig.3 illustrates the requirements that drive the tolerance specifications for the placement of the basic elements in a modular gas system.

Fig. 3 is not intended to limit the numerous other configurations and elements that may be used to form such a gas system. Clearly, other configurations, blocks, manifolds and functional elements are conceivable. For example, end plates 306 may be designed to mount to the mounting plane 311 directly, gas sticks may be created by base blocks that mount directly to the mounting plane without a manifold, various elements may be coupled to the mounting plane with the assistance of an elbow bracket that mounts directly to the mounting plane, etc. For this reason, all elements that may possibly be mounted to the mounting plane, either with their current design or with a modification to their current design, will be now be referred to as "modular blocks".

Various embodiments exist according to the present invention; however, all the embodiments have two essential features: centering elements and tracks. Fig. 4 shows a gas panel 400 created by the present invention. Numerous tracks 401 are shown. Centering elements 402 are not visible when they anchor the modular blocks 403 because they reside beneath the modular blocks 403 inside the track 401. A subset of the elements labeled as modular blocks 403 in Fig. 4, as shown, do not mount directly to the mounting plane 404. However, as previously stated, it is conceivable that these blocks may, with some modification, have such a capability. As such, they are all labeled as modular blocks 403. Tracks 401 run along the lengthwise (x) dimension. For the reasons already discussed, there is a very limited tolerance for curvature of the tracks 401. Typically, no more than .002" to .003" per foot is acceptable. The tracks 401 serve as the primary reference for the placement of modular blocks 403 with respect to the surface of the mounting plane 404. The centering elements 402 are designed such that they easily add to,

separate from, move upon and anchor to the tracks. Furthermore, the relative geometries of the tracks 401 and centering elements 402 are such that the centering elements may be anchored within a +/-.003" tolerance in the z direction. The centering elements 402 are coupled, either directly or indirectly, to the modular blocks 403. In the preferred embodiment there are at least two centering elements used to anchor a modular block on at least two separate tracks. The result is a mounting plane system with the capability to rapidly and easily place and replace modular blocks 403 with negligible relative deviation across the surface of the mounting plane 404.

As discussed, requirements of a mounting plane system include: 1) the ease of manufacture; 2) the ability to easily and rapidly add or remove centering elements from tracks located in the mounting plane and 3) the ability to place the modular block anywhere within a continuous range of locations.

The preferred embodiment, shown in Figs. 5a through 5f, meets all the above requirements. Referring to Figs. 5a through 5c, the tracks 501 are cavities that are milled into the mounting plane 504. The mounting plane 504 can be a plate of black anodized aluminum. The cavities 501 run along the length of the mounting plane 504 and are milled within a tolerance of .002"-.003" by standard CNC (Computer Numerically Controlled) machining equipment. Because the tracks 501 are formed by standard machining equipment, the manufacturing cost of the mounting plane is minimized. The centering elements 502, shown in Fig. 5b, are trapezoidal or dovetail shaped nuts (dove nuts) that fit within the cavity 501 and may enter the track 501 on either end 505 of plane 504. Because the depth of the cavity 501 (.188"-.191") is greater than the thickness of the dove nut 502 (.147"-.153") the dove nuts 502 slide easily within the cavity 501. Thus the dove nuts 502 may be placed at any continuous location along the track 501. The dovetailed shapes of the cavity 501 and dove nut 502 are for anchoring the centering elements 502 with high precision. This aspect of the mounting plane system is discussed later. The thickness of the mounting plane is any thickness sufficient to prevent bowing of the plane 504 due to the presence of the cavities 501.

Figs. 6a through 6d show alternate embodiments. In the second embodiment, shown in Figs. 6a through 6c,, the mounting plane is a concept as opposed to a physical element. That is, the tracks 601 are cavities that are milled into metal extrusions 606. The extrusions 606 are then fitted, with the assistance of dowel pins 607, into a larger framework 608 that is capable of holding multiple

extrusions 606. Dove nuts 602 similar to those used in the preferred embodiment are also used in the second embodiment. In the third embodiment, shown in Fig. 6d, extrusions have been replaced by rails 609. Thus there is no cavity. Also, instead of dove nuts, locator bars 610 are used as the centering elements that glide along the rails and anchor the modular blocks to the rails.

An additional requirement of the mounting plane concept is the ability to mount or anchor the modular blocks with high precision. As depicted back in Figs. 5a and 5b, the preferred embodiment includes a narrowing cavity 501 within the planar structure 504 and an anchoring element (a dove nut, 502) that slides into the cavity 501 such that the threaded hole 507 of the dove nut 502 is nearly perfectly centered (within tolerances of +/- .003") with respect to the width of the opening 506 of plane 504. As Fig. 5c shows, modular blocks 512 have through holes 514 through which bolts 513 are placed and then threaded into the threaded hole 507 of dove nut 502. In this manner, modular blocks 512 are mounted to the mounting plane 504 with comparable placement tolerance on the plane as the dove nut 502. Most modular blocks 512 have at least four through holes 514 which mount bolts 513 to dove nuts 502 that are placed in at least two different tracks/cavities 501.

The relative geometries of the cavity 501 and the dove nut 502 is critical to the mounting plane's ability to precisely place the threaded hole 507 of each dove nut 502 in the center of opening 506. As Figs. 5a through 5e show, both the cavity 501 and the width of the dove nut 502 taper or narrow inward at an angle of approximately 60 degrees. The threaded hole 507 of the dove nut 502 is centered in the opening 506 of the plane 504 by moving the dove nut 502 into the cavity 501 in the direction of the cavity's 501 narrowing width until the dove nut 502 is snug against the surface of the cavity 508. This movement is easily performed by the activity of threading the hole 507 with the bolt 513 (refer to Fig. 5c). As Fig. 5f shows, the head of bolt 513 is wider than the hole 514 that bolt 513 is inserted into. As a result, as the bolt 513 is threaded into dove nut 502, the position of bolt 513 is fixed and dove nut 502 slides upward into cavity 501 toward the opening 506. This movement continues with the threading until the dove nut 502 is snug. Fig. 5f shows the dove nut 502 snug against the surface of the cavity 508. In this manner, the dove nut's threaded hole 507 and bolt 513 are "self" centered in opening 506.

It is important to note that the concept of placing an element with high precision by use of a narrowing cavity is applicable to numerous alternate embodiments. That is, different geometries than those of the preferred embodiment

will still enable the highly precise placement of an element. For example, a different angle than 60 degrees; or even a different shape altogether such as cylindrical cavity and centering element are all acceptable alternatives. The second alternate embodiment, shown back in Fig. 6a, has a region that narrows in a direction opposite to the opening in the mounting plane. This embodiment is capable of self centering if the bolt used to thread the dove nut is nearly the same as the width of the opening in the mounting plane.

The mounting plane design also accounts for additional functional and manufacturing requirements that are related to the self centering mechanism. These include: 1) ensuring that, in a high volume manufacturing environment, all manufactured dove nuts 502 will fit within all manufactured cavities 501 and that, for each dove nut 502 and cavity 501, the self centering capability is preserved; 2) preventing slippage of the dove nut 502 inside the cavity 501 once a modular block is mounted to it; and 3) preventing dove nut 502 from slipping through opening 506 such that accurate centering of the bolt 513 is lost.

As discussed, the ideal design of the mounting-plane centering mechanism equates the angle of the cavity's 501 taper with the angle of the taper of the dove nut's 502 width. However, as a result of the unavailability of an affordable manufacturing process that mills the cavity 501 and dove nut 502 with zero tolerance, the mounting plane design must account for the possibility that either the cavity 501 or dove nut 502 may not be milled at exactly 60 degrees. That is, if the design point for the taper of both the cavity 501 and the dove nut 502 was 60 degrees, with current affordable manufacturing processes, it is likely that the angle of the taper for many dove nuts 502 would exceed the angle of the taper for the cavity 501. In this instance the dove nut 502 will not fit inside the cavity 501 and a percentage of dove nuts 502 would have to be scrapped. Therefore the angle at which the cavity 501 is milled is slightly offset from the angle at which the dove nut 502 is milled. Specifically, the cavity 501 is milled at angles between 60.0 and 60.5 degrees and the angle of the dove nut 502 is milled at angles between 59.0 and 60.0 degrees. This guarantees that all manufactured dove nuts 502 will fit inside all manufactured cavities 501. Furthermore, this guarantees that the self centering capability is preserved. Under worst case conditions (e.g. 60.5 degree cavity 501 and a 59.0 degree dove nut), when bolt 513 is tightened, dove nut 502 is sufficiently snug in cavity 501 such that bolt 513 is still centered in opening 506. Obviously, depending on the geometry chosen for the cavity and centering

element, many different embodiments are conceivable where the tapered angles of the cavity and centered element differ slightly in order to guarantee a high manufacturing yield and maintain the self centering capability.

Because the modular blocks are used to create ultra clean gas systems, once a modular block is mounted to a dove nut 502 it is imperative that the modular block stays fixed in place. Therefore the mounting plane design includes grooves 509 on the surface of the dove nut 502. These grooves simply increase the friction of the interface between the dove nut 502 and the cavity 501 thus movement of the dove nut 502 within the cavity, after the modular block has been anchored, is not a concern. Furthermore, the dove nut 502 is made of 304 stainless steel and the plane 504 is made of Ryerson M6 aluminum. Thus the dove nut 502 is made of a harder material than the plane 504. This allows the dove nut to bite into the plane which further increases the friction of the interface. Obviously many different embodiments exist regarding proper materials for dove nuts 502 and planes 504. The principle concept is that the dove nut 502 is harder than the plane 504.

Another functional requirement of the mounting plane design is preventing dove nut 502 from slipping through opening 506 such that accurate centering of the bolt 513 and proper fastening is lost. In order to meet this requirement, the smallest width of the dove nut 502 is larger than the opening 506 (refer to Fig. 5f). That is, if the narrowest width of the dove nut 502 was equal to the width of the opening 506, an edge of dove nut 502 could slip through the opening 506. This would orient the dove nut 502 such that proper self centering and fastening of the dove nut 502 would be lost. Under the preferred embodiment, the narrowest width of the dove nut is .195" +/- .003" and the width of the opening 506 is between .170" and .173". Embodiments where the cavity narrows in a direction away from the opening do not have this requirement as there is no tip region. In such an embodiment, the cavity is surrounded by the plane material on all sides where the centered element is pressed snug against the cavity.

As is well known in the art, the thickness of the dove nut 502 need not be larger the diameter of the bolt . Under the preferred embodiment, the dove nut's thickness is .15" and the threaded hole is 8-32 UNC 2B. The threaded hole 507 is centered on the dove nut 502 and extends through the thickness 512 of the dove nut 502. The length of the dove nut 502 is .500".

A fourth desired featured of the mounting plane system is the ability to hold dove nuts in place in the cavity against a variety of undesired forces that would tend

to move the centering element along the track (e.g. gravity, or an accidental "bump" against the mounting plane). A principal motivation for the mounting plane is to quickly and easily rebuild a gas panel. In order to facilitate the rapid reconfiguration of a gas panel, it is necessary in such a case to have a mechanism such that the dove nuts 502 do not slide along the cavities 501.

Fig. 7a shows a spring 700 used to press the dove nut 707 into the cavity, toward the cavity opening 706, with sufficient force such that the dove nut 707 does not slide down the length of the cavity due to an undesired force. The spring 700 has a bowed region 701, two stem regions 702 and two tab regions 703. Under the preferred embodiment, it is critical that the spring constant is: 1) high enough to hold the dove nut 502 in place against an undesired force and 2) low enough to easily separate the dove nut 502 from the cavity surface 508 so that the dove nut 502 may be easily moved up and down the lengths of the cavities 501. The spring constant increases as 1) the bulk modulus increases; 2) the radius of curvature for the bowed region 702 decreases and 3) the thickness of the material used for the spring increases. The preferred embodiment uses a spring having beryllium copper as its material, a radius of curvature of .226" and a thickness of .005". The width of the bowed region 701 is .150".

The stem regions 702 of the spring are .075" and the tab regions 703 are .078". The purpose of the tab regions 703 is to keep the spring attached to the dove nut 707 while the dove nut is in the cavity. Thus the width of the tabs must be sufficient to catch a wide area of the ends of the dove nut 707. As Fig. 7b shows, when it is desired to move the dove nut along a cavity 702 length, the spring is disengaged simply by pressing the dove nut 707 away from the opening 706. The tabs 703 move away from the edges of the dove nut 707 when the dove nut is pressed in this manner. In the preferred embodiment, the tab widths are .216" and the tab lengths are .078".

Referring back to Fig. 5f, a guide 511 is shown that is milled in the plane 504 adjacent to the cavity 501. There are two purposes to guide 511. First, guide 511 guides the spring and keeps it in place at all times when the dove nut 502 is inside the cavity 501. The width of bowed region 701 (ref. Fig. 7) is slightly less than the width of guide 511 so that dove nut 502 does not rotate around the y axis in the cavity 501. Second, guide 511 prevents bolt 513 from "bottoming out" or touching the mounting structure 504. The width of the guide is between .170" and

173". This is equal to the width of the opening 506 and makes manufacturing of the plane 508 less complicated.

Thus, a novel mechanism of mounting a set of blocks has been described which allows the flexible configuration of weldless and tubeless gas panels.

IN THE CLAIMS

We claim:

1. An apparatus capable of centering a first element, comprising:

a) a first element, said first element having a width and a thickness, said first element having a varying width that decreases along the axis of said first element's thickness; and

b) a second element, said second element having a cavity, said cavity having a width and a depth, said cavity having a varying width that decreases along the axis of said cavity's depth, said variation in depth of said cavity substantially the same as said variation in said first element's width such that said first element is centered by pressing or pulling said first element insaid cavity in the direction of said decreasing width until said first element is snug against said second element.

2. The apparatus of claim 1 wherein said second element has an opening at the surface of said second element such that said cavity is exposed.

3. The apparatus of claim 1 wherein said first element has grooves to increase the friction between said first element and said second element when said first element is pressed or pulled snug against said second element.

4. The apparatus of claim 1 wherein said first element is composed of a harder material and said second element is composed of a softer material.

5. The apparatus of claim 1 wherein said first element's width narrows at a slightly greater rate than the rate at which the width of said cavity narrows.

6. The apparatus of claim 1 wherein, at the region where said first element is pressed or pulled snug against said second element, the smallest width of said first element is larger than the smallest width of said cavity.

7. The apparatus of claim 2 wherein said first element has means for coupling to, directly or indirectly, a modular block for use in a modular gas system,

said centering of said first element used as a means to place said modular block with high precision on said surface.

8. An apparatus capable of centering a first element, comprising:

a) a first element, said first element having a width and thickness, said first element having a varying width that decreases along the axis of said first element's thickness;

b) a second element, said second element having a cavity, said cavity having a width and a depth, said cavity having a varying width that decreases along the axis of said cavity's depth, said variation in width of said cavity substantially the same as said variation in said first element's width such that said first element is centered by pressing or pulling said first element in said cavity in the direction of said decreasing width until said first element is snug against said second element; and

c) a third element, located in said cavity, capable of pressing or pulling said first element against said second element in said cavity in said direction of decreasing width such that said first element does not move in said cavity.

9. The apparatus of claim 8 wherein said second element has an opening at the surface of said second element such that said cavity is exposed, said opening having a width.

10. The apparatus of claim 9 further comprising a fourth element, said fourth element attached to said first element such that said fourth element is centered in the width of said opening, said fourth element located in said opening.

11. The apparatus of claim 8 wherein said first element has grooves to increase the friction between said first element and said second element when said first element is pressed or pulled snug against said second element.

12. The apparatus of claim 8 where said first element is composed of a harder material and said second element is composed of a softer material.

13. The apparatus of claim 8 wherein said first element's width narrows at a slightly greater rate than the rate at which the width of said cavity narrows.

14. The apparatus of claim 8 wherein, at the region where said first element is pressed or pulled snug against said second element, the smallest width of said first element is larger than the smallest width of said cavity.

15. The apparatus of claim 9 wherein said first element has means for coupling to, directly or indirectly, a modular block for use in a modular gas system, said centering of said first element used as a means to place said modular block with high precision on said surface.

16. An apparatus capable of mounting a block with high precision, comprising:

a) a bolt;

b) a dove nut, said bolt attached to said dove nut, said dove nut having a width and thickness, said dove nut having a varying width that decreases along the axis of said dove nut's thickness;

c) a plate having a cavity, a guide, and an opening, said cavity and said guide having a width and a depth, said cavity having a varying width that decreases along the axis of said cavity's depth such that said variation in said dove nut's width is substantially the same as said variation in said cavity's width, said guide adjacent to said cavity, said plate surrounding said cavity and said guide on all sides except at said opening, said opening located at the surface of said plate such that said cavity is exposed, said opening having a width, said width of said opening greater than said width of said bolt;

d) a block, said block requiring high precision placement on said plate, said block attached to said plate by threading, through said block, said bolt into said dove nut, said threading resulting in the movement of said dove nut into said direction of narrowing width of said cavity until said dove nut is snug against said plate so that said bolt is centered in the width of said opening such that said block is placed on said plate with high precision; and

d) a spring located in said cavity capable of pressing said dove nut against said plate in said cavity in said direction of narrowing width of said cavity such that said dove nut does not move in said cavity.

17. The apparatus of claim 16 wherein said spring comprises a bowed region, two stem regions and two corner regions, said bowed region having a first edge and a second edge, said first edge of said bowed region connected to a first edge of a first stem region, said second edge of said bowed region connected to a first edge of a second stem region, said first stem region having a second edge, said second stem region having a second edge, said second edge of said first stem region connected to a first corner region, said second edge of said second stem region connected to a second corner region said first and second corner regions used for coupling said spring to said dove nut.

18. The apparatus of claim 16 wherein said dove nut has grooves to increase the friction between said dove nut and said plate when said dove nut is pulled snug against said plate by threading said bolt into said dove nut.

19. The apparatus of claim 16 where said dove nut is composed of a harder material and said plate is composed of a softer material.

20. The apparatus of claim 16 wherein said dove nut's width narrows at a slightly greater rate than the rate at which the width of said cavity narrows.

21. The apparatus of claim 16 wherein, at the region where said dove nut is pulled snug against said plate, the smallest width of said dove nut is larger than the width of said cavity.

22. The apparatus of claim 16 wherein said block is a modular block for use in a modular gas system, said centering of said bolt used as a means to place said modular block with high precision on said plate.

23. An apparatus capable of rapidly adjusting the position of modular blocks, said apparatus comprising:

a) a plurality of first elements;

b) a plane, said plane having a surface and a means for guiding said first elements on an axis such that each of said first elements moves easily and continuously along said axis, said plane having at least one of said means for guiding said first elements; and

c) a plurality of modular blocks, said modular blocks having means for coupling each of said modular blocks to at least one of said first elements such that each of said modular blocks may be placed and mounted on said surface of said plane at any position, continuously along said axis, such that each of said modular blocks has at least one neighboring modular block, such that said neighboring modular blocks relate to each other, such that said relationships among the plurality of modular blocks form a system on said surface of said plane.

24. The apparatus of claim 23 further comprising means for holding said first element in a desired position of said axis such that without said means for holding said first element, said first element would move due to gravitational force.

25. The apparatus of claim 23 wherein said modular block is for use in a modular gas system.

26. An apparatus for rapidly adjusting the position and accurately placing a modular block on a planar or linear structure, said apparatus comprising:

(a) a plurality of first elements, each of said first elements having a width and a thickness, each of said first elements having a varying width that decreases along an axis of said first element's thickness;

(b) a planar structure, said planar structure having a surface, at least one cavity and at least one opening such that there is one opening for each cavity, said opening exposing said cavity to said surface, said opening having a width, said cavity having a width, a depth and a length, each of said first elements capable of entering said cavity, each of said first elements capable of moving easily and continuously in said cavity in either direction along the axis of said length of said cavity such that each of said first elements can be placed at any position along said axis of said length of said cavity, said cavity having a varying width that decreases in a direction of said cavity's depth, said variation in said cavity substantially the same as said variation in said thickness of each of said plurality of first elements;

(c) a plurality of modular blocks, each of said modular blocks having means for mounting each of said modular blocks to at least one of said first elements such that said first element moves in said direction of said decreasing width of said cavity such that each of said modular block is mounted with high

precision with respect to said width of said opening in said planar structure, each of said modular blocks having at least one neighboring modular block such that said neighboring modular blocks relate to each other such that said relationships among the plurality of modular blocks form a system on said surface of said planar structure.

27. The apparatus of claim 26 further comprising a plurality of bolts,each of said bolts used as a means for coupling each of said modular blocks to at least one of said first elements, each of said plurality of modular blocks having at least one hole through which a bolt is placed when coupling a modular block to said first element, each of said first elements having threaded holes for coupling said bolt to said first element through said opening in said planar structure such that threading said bolt into said threaded holes results in the movement of said first element in the direction of said decreasing width of said cavity such that said bolt is centered in said opening of said planar structure such that said modular block is mounted with high precision on said planar surface.

28. The apparatus of claim 26 further comprising means for holding said first element in a desired position of said axis of said length of said cavity such that without said means for holding said first element, said first element would move due to gravitational force.

29. The apparatus of claim 26 wherein said modular block is a modular block for use in a modular gas system such that said high precision mounting is required for correct operation of said gas system.

30. An apparatus for rapidly adjusting the position and accurately placing a modular block on a planar or linear structure, said apparatus comprising:

(a) a plurality of dove nuts, each of said dove nuts having a width and a thickness, each of said dove nuts having a varying width that decreases along an axis of said dove nut's thickness, each of said dove nuts having threaded holes;

(b) a planar structure, said planar structure having a surface, at least one cavity and at least one opening such that there is one opening for each cavity, said opening exposing said cavity to said surface, said opening having a width, said cavity having a width, a depth and a length, each of said dove nuts capable of

entering said cavity, each of said dove nuts capable of moving easily and continuously in said cavity in either direction along the axis of said length of said cavity such that each of said dove nuts can be placed at any position along said axis of said length of said cavity, said cavity having a varying width that decreases in a direction of said cavity's depth toward said opening, said variation in said cavity substantially the same as said variation in said thickness of each of said plurality of dove nuts, said planar structure having a guide, said guide located adjacent to said cavity;

(c) a plurality of bolts;

(d) a plurality of modular blocks, each of said modular blocks having at least one hole, each of said bolts capable of threading into said dove nut while said bolt is located in said hole such that said threading results in the movement of said dove nut in said direction of said decreasing width of said cavity such that each of said threaded bolt is centered in said width of said opening of said planar structure, such that said modular blocks is mounted with high precision with respect to said width of said opening in said planar structure, each of said modular blocks having at least one neighboring modular block such that said neighboring modular blocks relate to each other such that said relationships among the plurality of modular blocks form a system on said surface of said planar structure; and

e) a spring, said spring at least partially located in said guide, said spring used for holding said dove nut in a desired position of said axis of said length of said cavity.

31. The apparatus of claim 30 wherein said modular block is a modular block for use in a modular gas system such that said high precision mounting is required for correct operation of said gas system.

32. An apparatus capable of rapidly adjusting the position of modular blocks for use in a gas system, said apparatus comprising:

a) a plurality of first elements;

b) a plane, said plane having a surface and a means for guiding said first elements on an axis such that each of said first elements moves easily and

continuously along said axis, said plane having at least one of said means for guiding said first elements; and

c) a plurality of modular blocks, said modular blocks having means for coupling each of said modular blocks to at least one of said first elements such that each of said modular blocks may be placed and mounted on said surface of said plane at any position, continuously along said axis, such that each of said modular blocks has at least one neighboring modular block, each modular block having channels for channeling gas or fluid, each modular block having openings for said channels, said openings being disposed in standard locations such that neighboring modular blocks form continuous channels, such that said mounting of the plurality of modular blocks form a gas system on said surface of said plane.

33. The apparatus of claim 32 further comprising means for holding said first element in a desired position of said axis such that without said means for holding said first element, said first element would move due to gravitational force.

34. An apparatus for rapidly adjusting the position and accurately placing a modular block for use in a gas system on a planar or linear structure, said apparatus comprising:

(a) a plurality of first elements, each of said first elements having a width and a thickness, each of said first elements having a varying width that decreases along an axis of said first element's thickness;

(b) a planar structure, said planar structure having a surface, at least one cavity and at least one opening such that there is one opening for each cavity, said opening exposing said cavity to said surface, said opening having a width, said cavity having a width, a depth and a length, each of said first elements capable of entering said cavity, each of said first elements capable of moving easily and continuously in said cavity in either direction along the axis of said length of said cavity such that each of said first elements can be placed at any position along said axis of said length of said cavity, said cavity having a varying width that decreases in a direction of said cavity's depth, said variation in said cavity substantially the same as said variation in said thickness of each of said plurality of first elements;

(c) a plurality of modular blocks, each of said modular blocks having means for mounting each of said modular blocks to at least one of said first elements such

that said first element moves in said direction of said decreasing width of said cavity such that each of said modular block is mounted with high precision with respect to said width of said opening in said planar structure, each of said modular blocks having at least one neighboring modular block, each modular block having channels for channeling gas or fluid, each modular block having openings for said channels, said openings being disposed in standard locations such that neighboring modular blocks form continuous channels, such that the plurality of modular blocks form a gas or fluid system.

35. The apparatus of claim 34 further comprising a plurality of bolts, each of said bolts used as a means for coupling each of said modular blocks to at least one of said first elements, each of said plurality of modular blocks having at least one hole through which a bolt is placed when coupling a modular block to said first element, each of said first elements having threaded holes for coupling said bolt to said first element through said opening in said planar structure such that threading said bolt into said threaded holes results in the movement of said first element in the direction of said decreasing depth of said cavity such that said bolt is centered in said opening of said planar structure such that said modular block is mounted with high precision on said planar surface.

36. The apparatus of claim 34 further comprising means for holding said first element in a desired position of said axis of said length of said cavity such that without said means for holding said first element, said first element would move due to gravitational force.

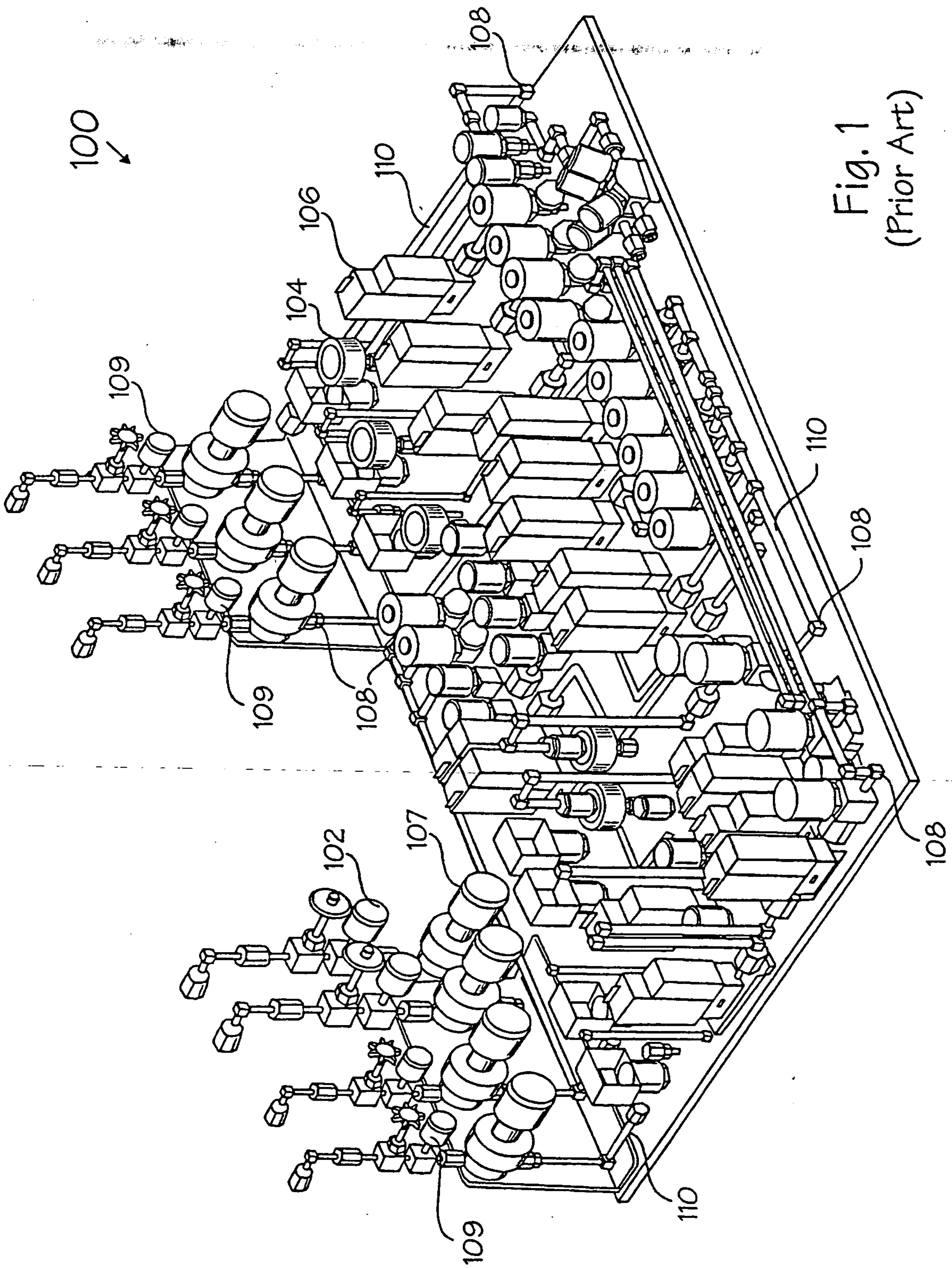
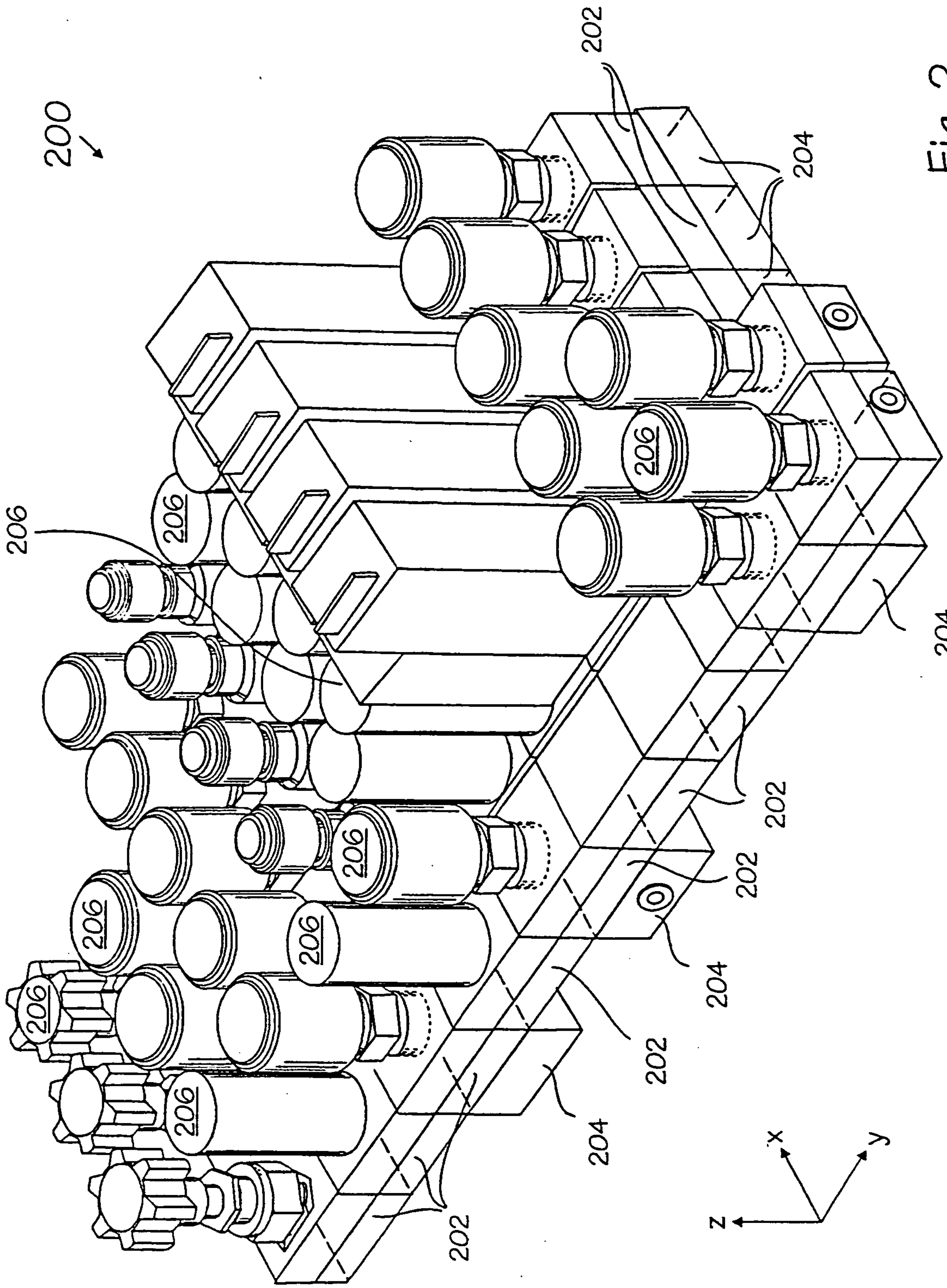


Fig. 1
(Prior Art)


200
202
202
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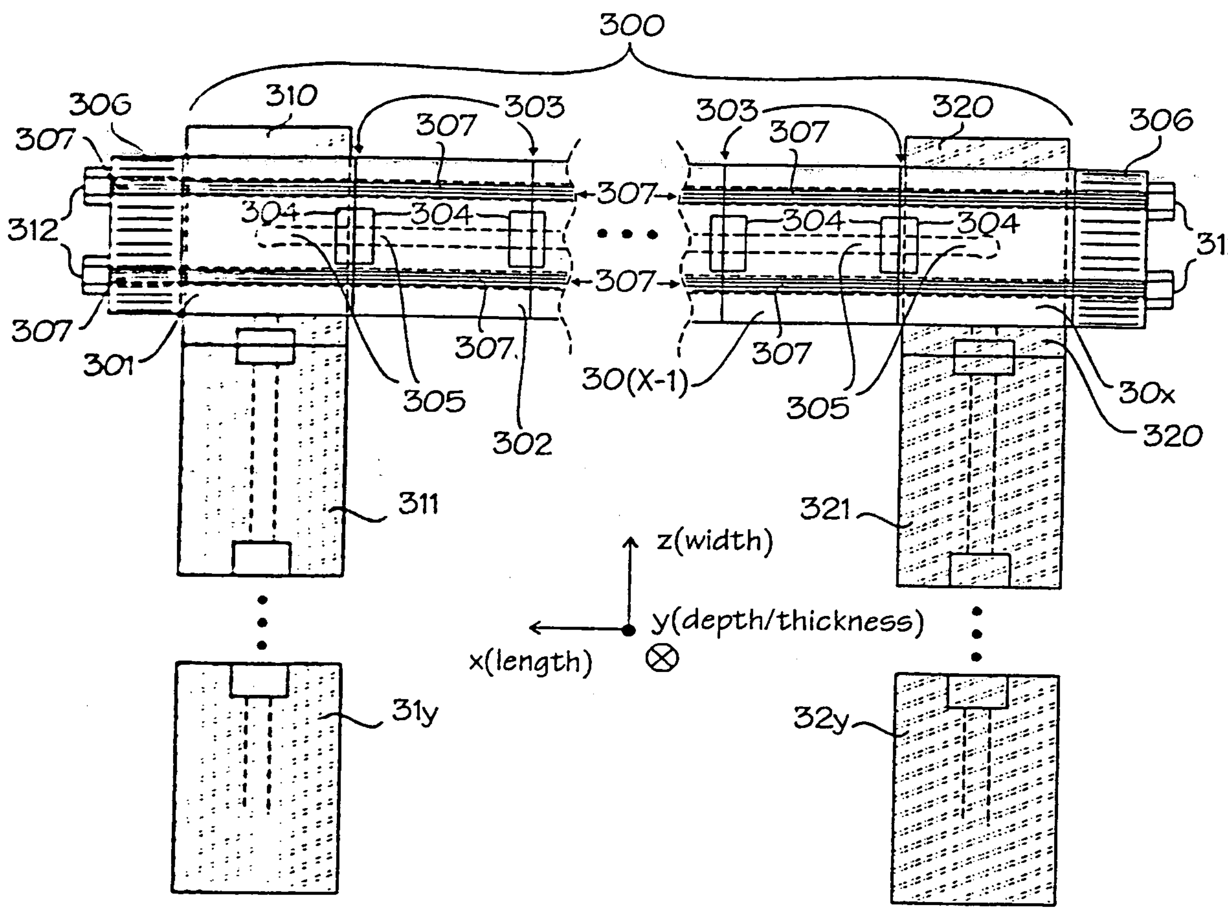
206
206
206
206
206
206
206
x
y
z

Fig. 2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303
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307
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307
312
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304
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307
304
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312
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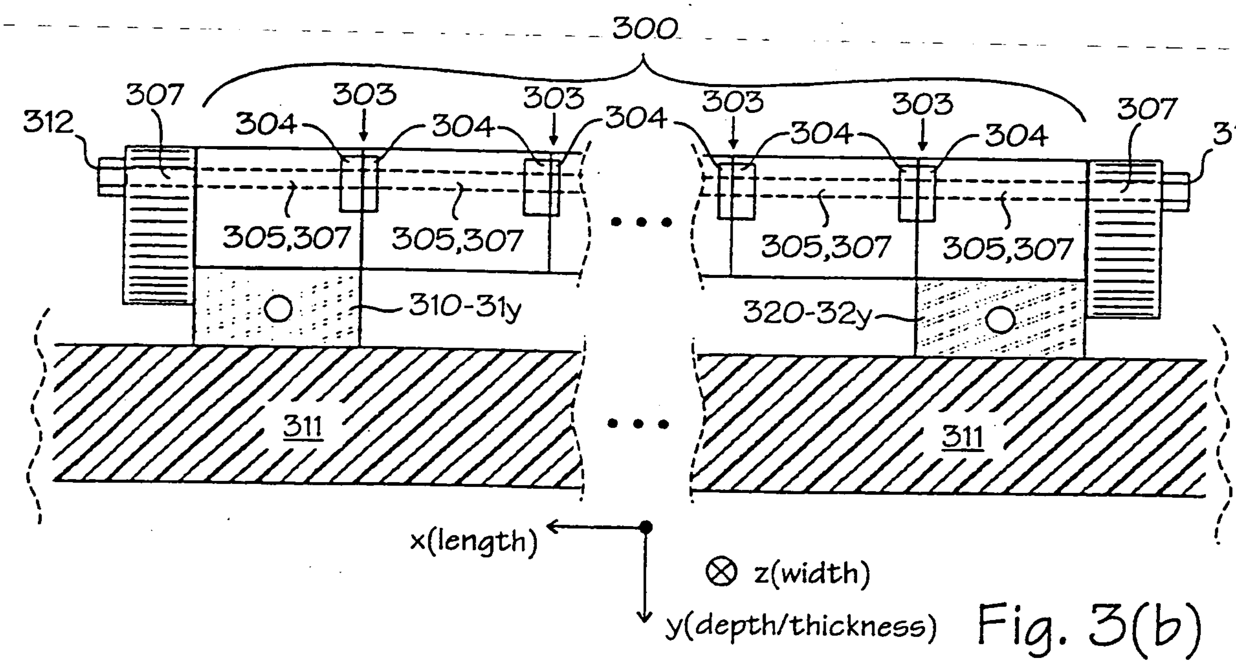
301
307
302
305
30(X-1)
307
305
30x
320
311
321
z(width)
y(depth/thickness)
x(length)
31y
32y

Fig. 3(a)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307
312
304
304
304
304
304
312
305,307
305,307
305,307
305,307
310-31y
320-32y
311
311
x(length)
z(width)
y(depth/thickness)

Fig. 3(b)

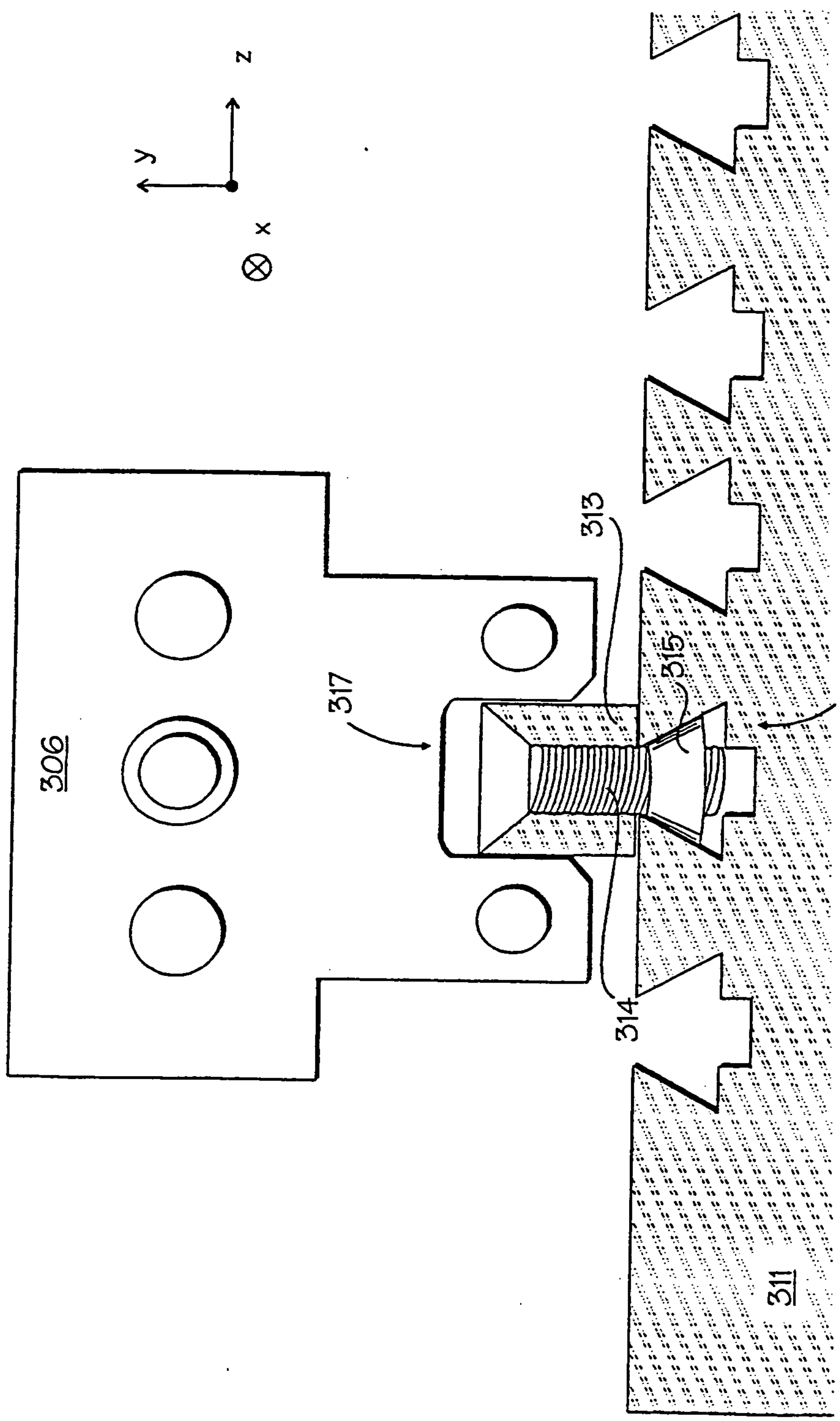
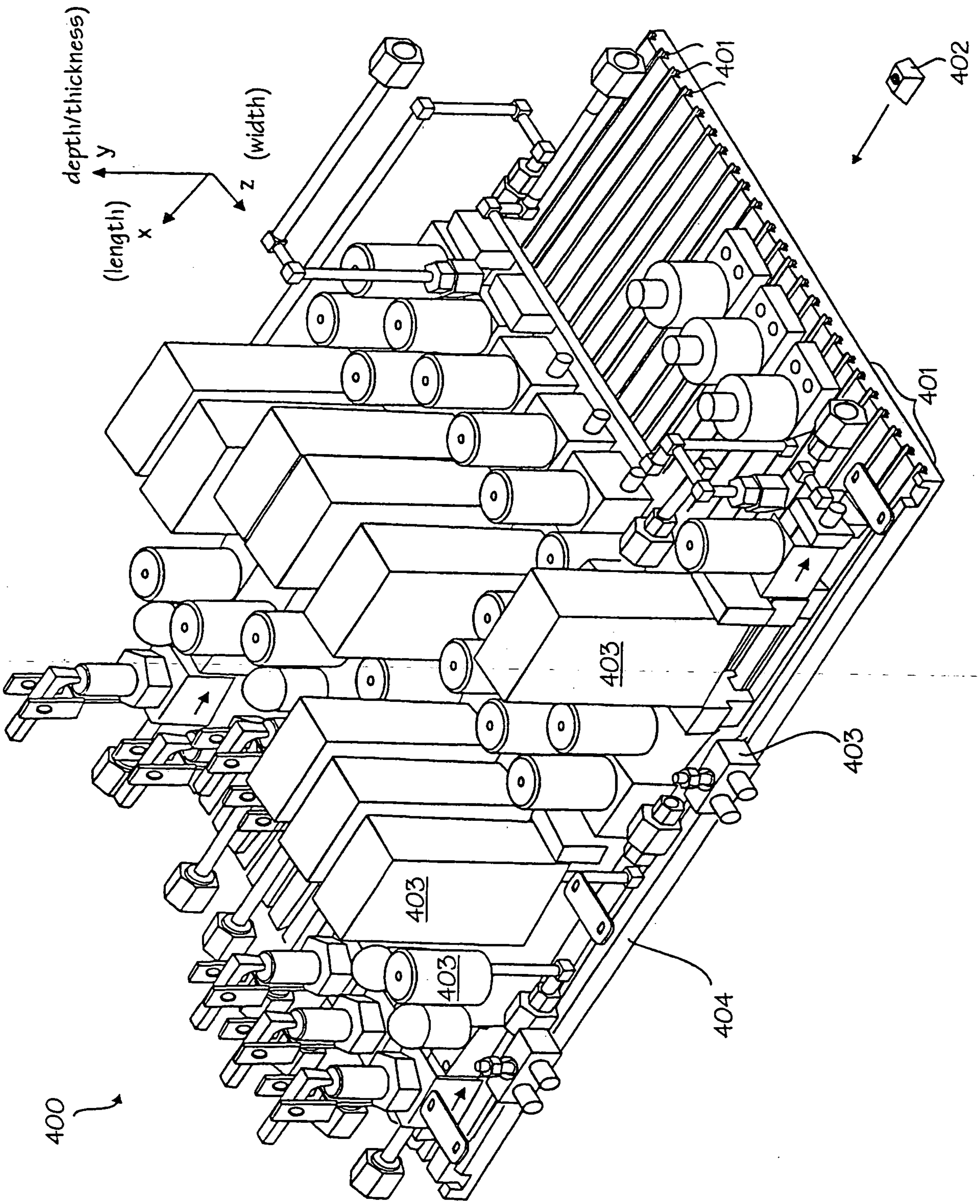


Fig. 3(c)

Fig. 4


depth/thickness
y
(width)
z
(length)
x
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401
402
403
403
403
403
404
400

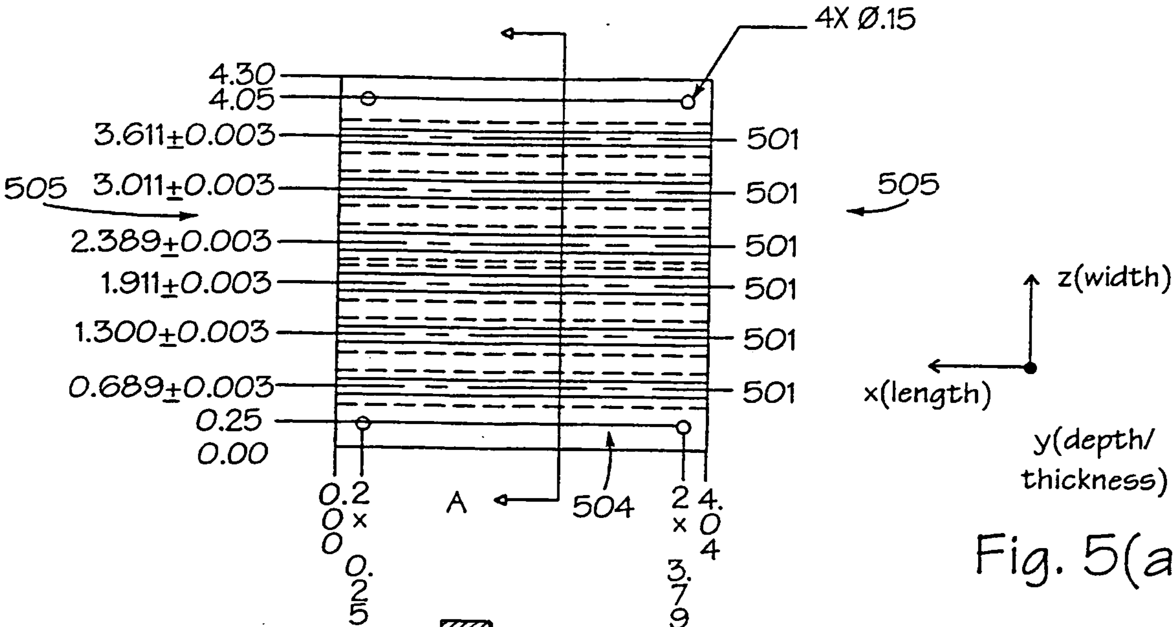


Fig. 5(a)

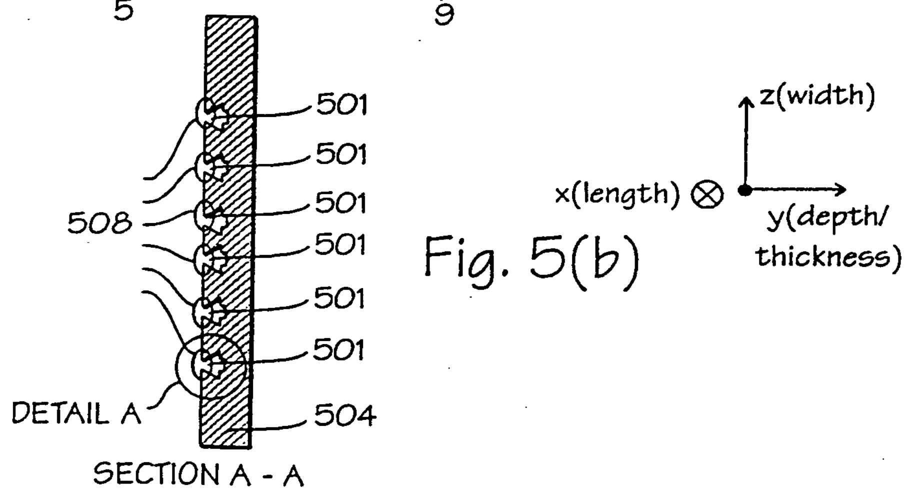


Fig. 5(b)

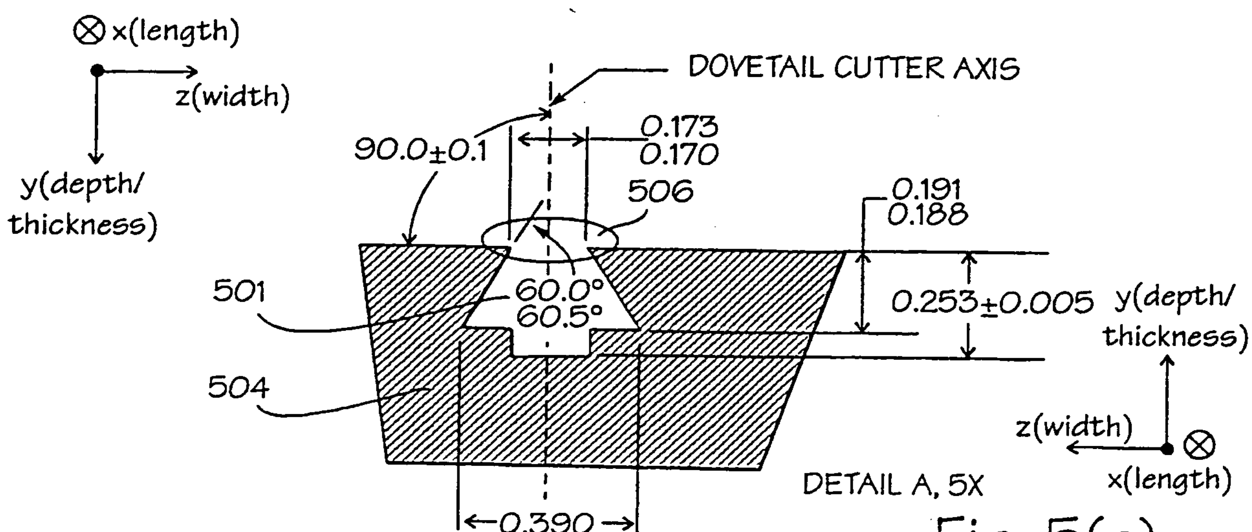
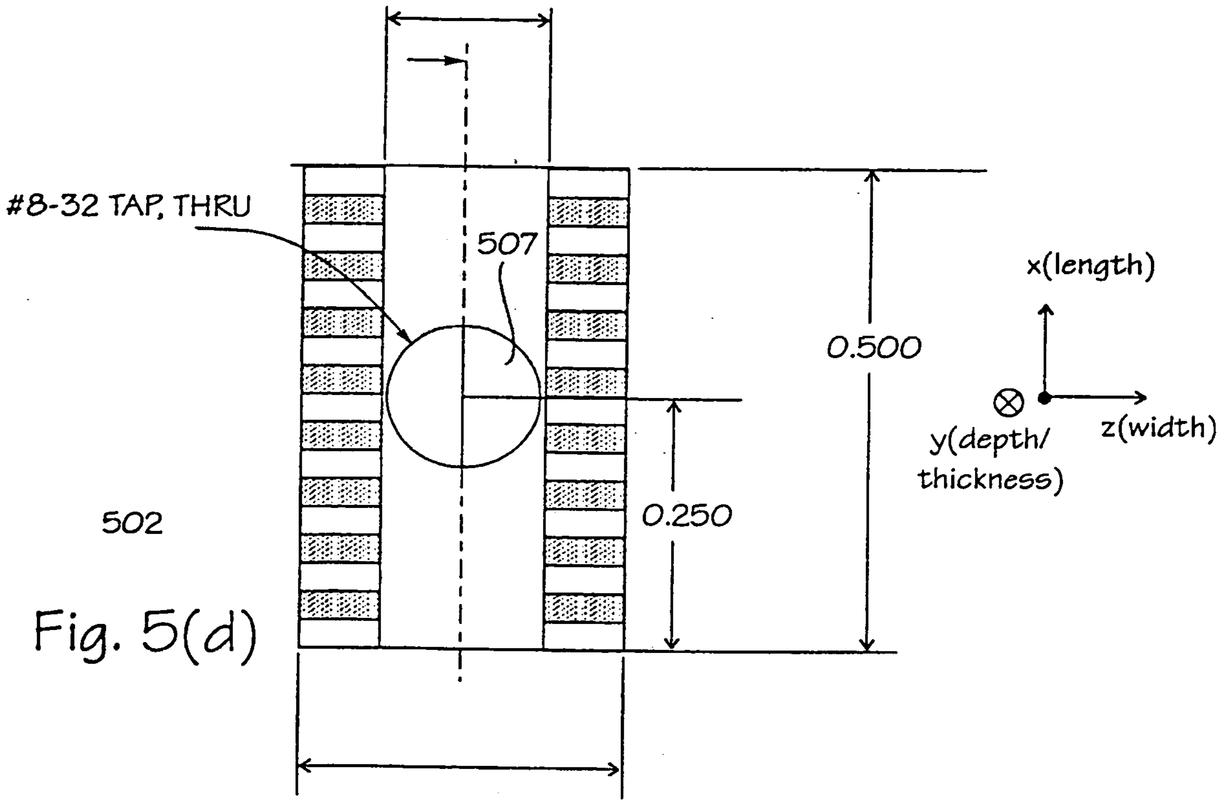
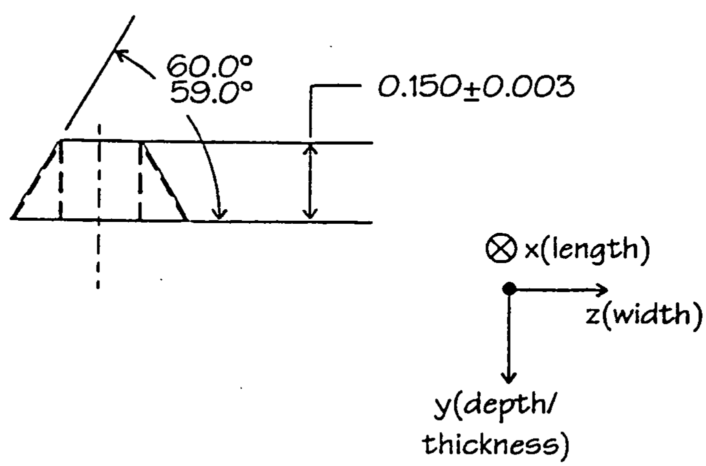


Fig. 5(c)



502

Fig. 5(d)



502

Fig. 5(e)

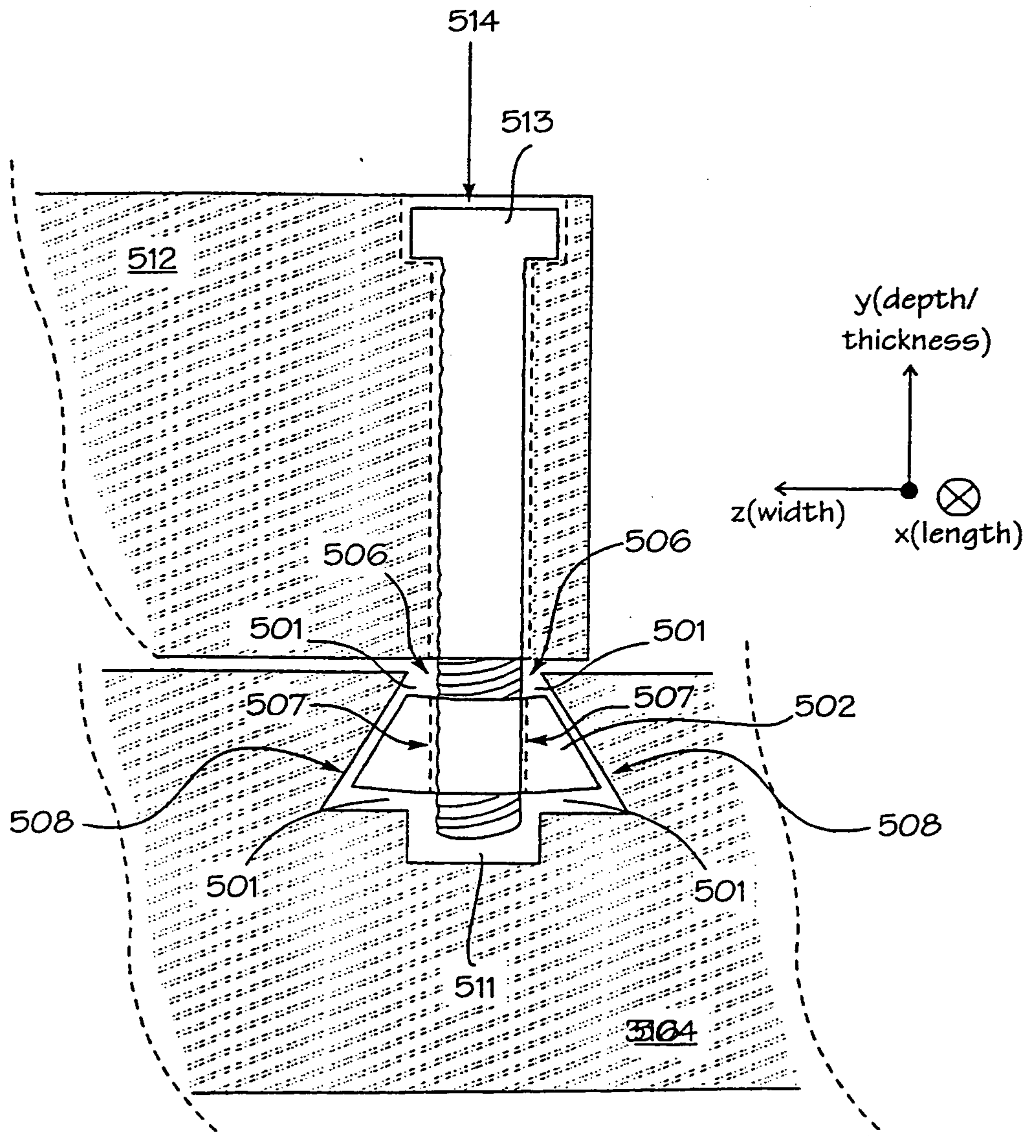

514
513
512
y(depth/
thickness)
z(width)
x(length)
506
506
501
501
507
507
502
508
508
501
501
511

Fig. 5(f)

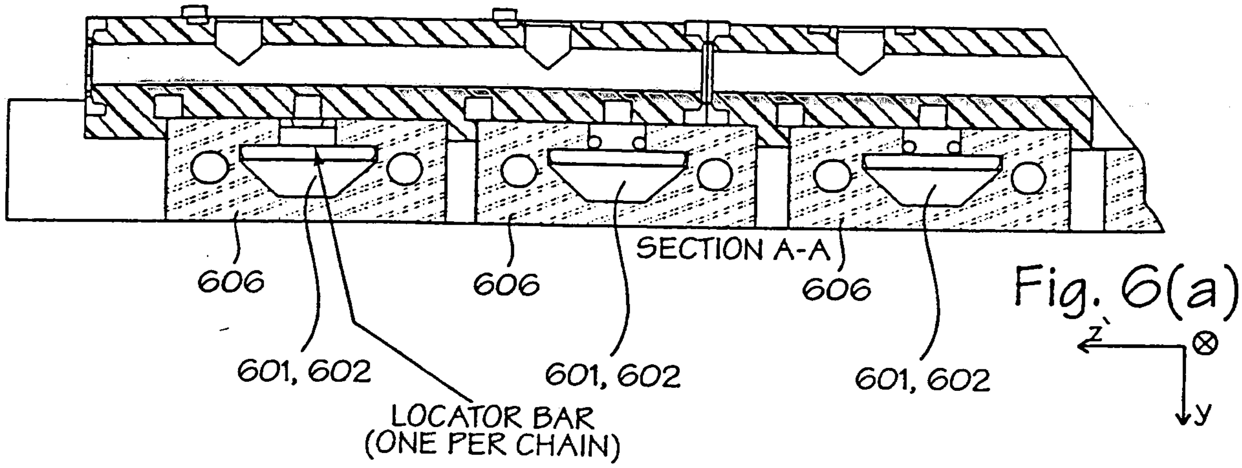


Fig. 6(a)

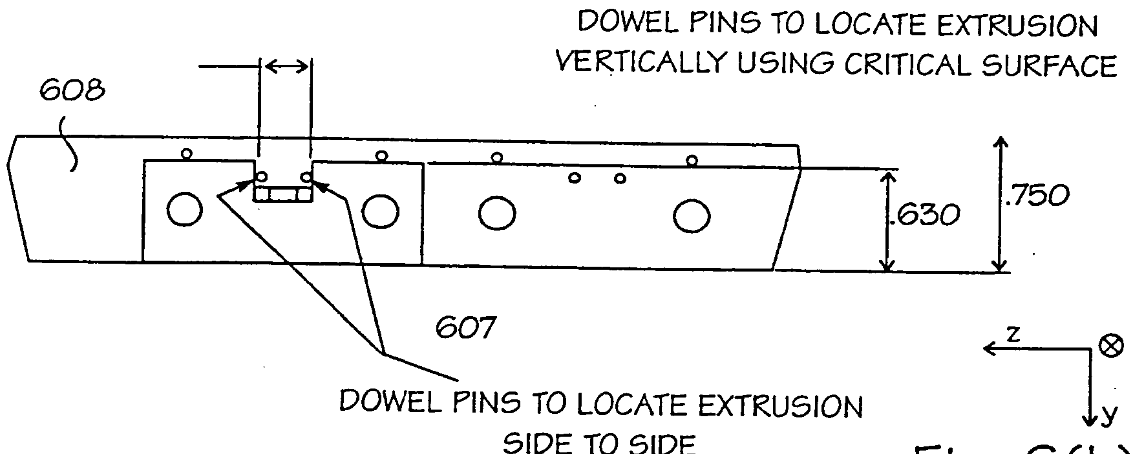


Fig. 6(b)

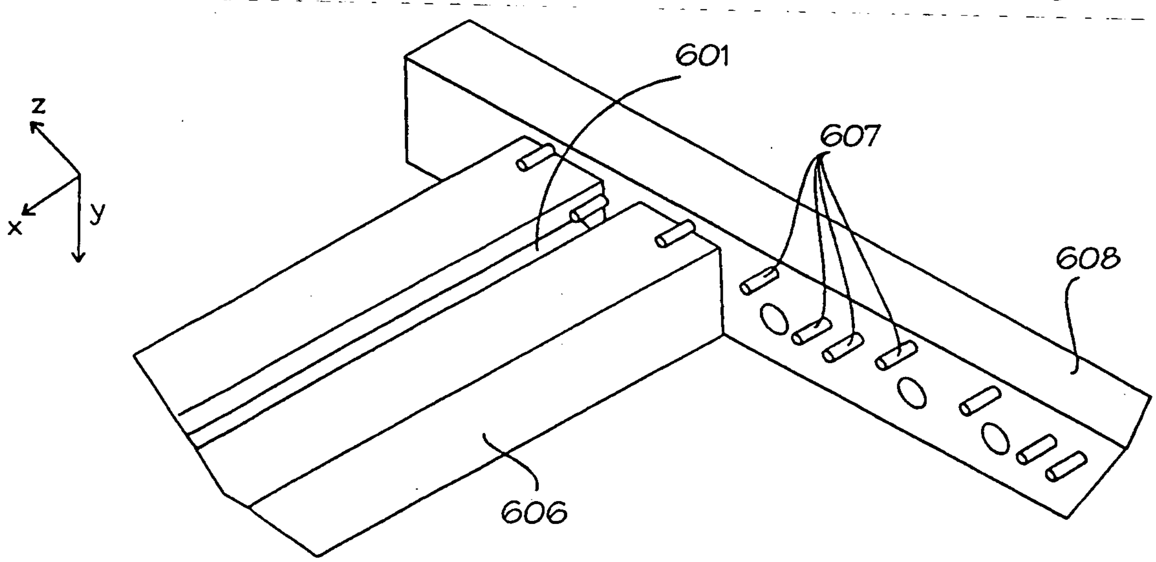


Fig. 6(c)

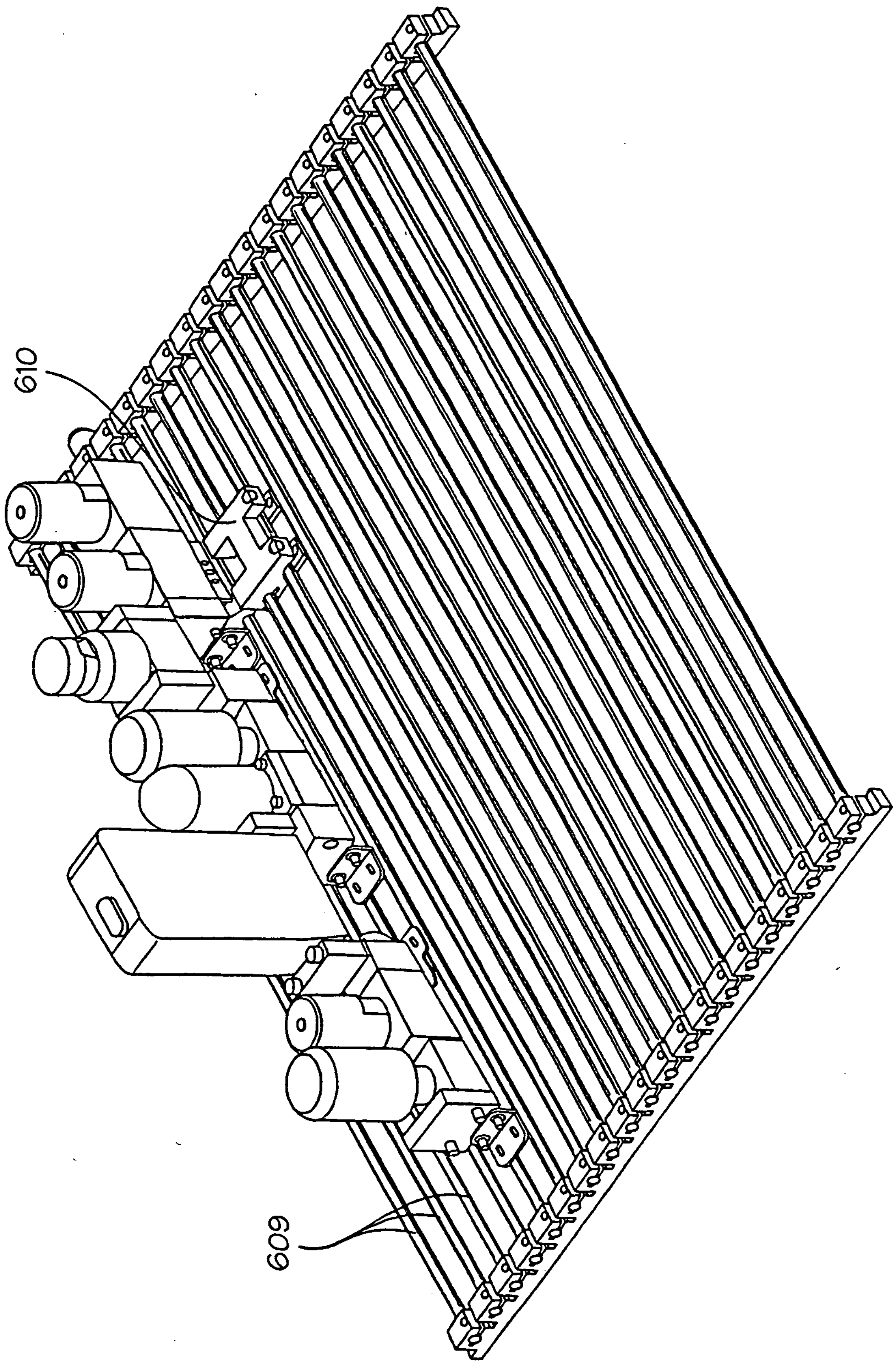


Fig. 6(d)

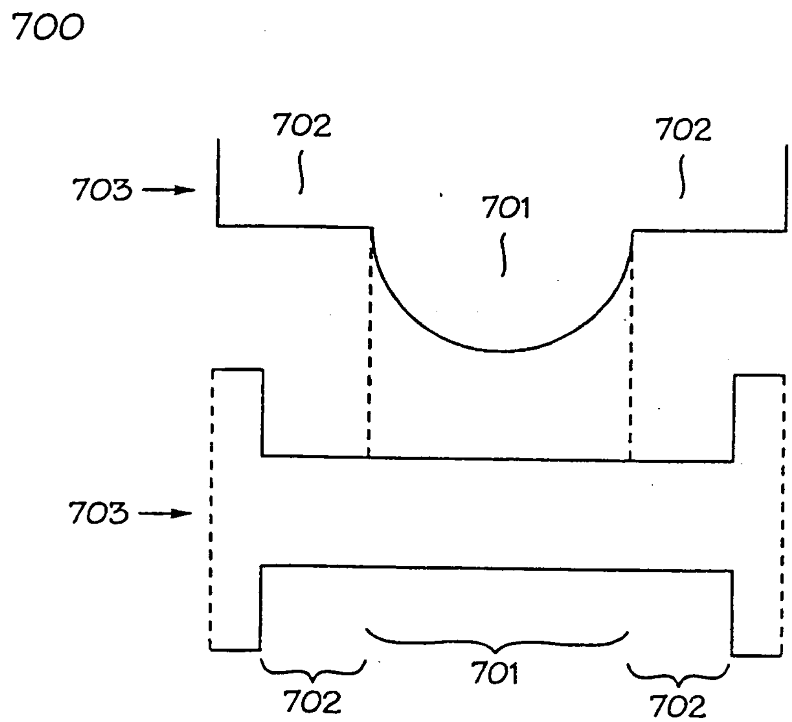


Fig. 7(a)

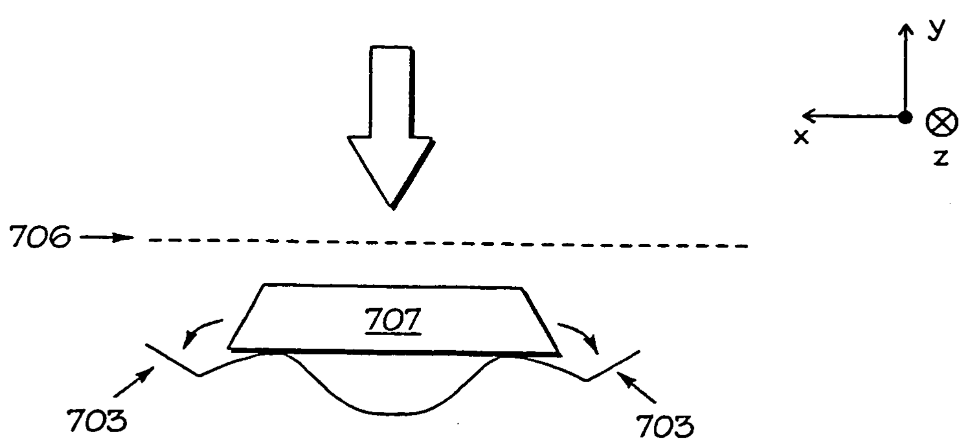


Fig. 7(b)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/11574

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :F16B 2/14; F16K 11/00 US CL :403/13, 374.3, 381; 137/884 According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols) U.S. : 403/13,14, 24, 334, 370, 374.1, 374.2, 374.3, 381, 404, 409.1; 137/104, 884; 411/84, 85, 104
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched NONE
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 4,687,425 A (TAKANO ET AL.) 18 AUGUST 1987 (18/08/87), see figs. 1-2.	1-2, 7-10, 15-16, & 22 ----------- 4-5,12-13, & 19-20
X -- Y	US 4,057,294 A (KREKELER) 08 NOVEMBER 1977 (08/11/77), see fig. 30.	1-2, 7-10, 15, 23-26, & 29 ---------- 4-5 & 12-13
X	US 744,559 A (KENDRICK) 17 NOVEMBER 1903 (17/11/03), see figs. 1-3.	1-3, 7-11, 15, & 23-25
X	US 5,275,074 A (TAYLOR ET AL.) 04 JANUARY 1994 (04/01/94), see fig. 6.	1-2, 6-10, 14-15, & 23-25

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 JULY 1998	02 OCT 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer HARRY C. KIM Diane Smith for Telephone No. (703) 308-2168

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/11574

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,370,081 A (BRILES) 25 JANUARY 1983 (25/01/83), see fig. 1.	4-5, 12-13, & 19-20
A	US 5,025,834 A (STOLL) 25 JUNE 1991 (25/06/91), see entire document.	1-36